Access to Geostationary Satellite Data Streams (GMS)

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There are five geostationary meteorological satellites surrounding the globe. This report introduces the GMS-5 operated by Japan Meteorological Agency (JMA). JMA's fifth satellite GMS-5 was launched in March 1994 and nicknamed 'HIMAWARI' or sunflower in Japanese. It is stationary at an altitude of 35800 kilometers above the equator, 140 degrees of east longitude.

The Visible and Infrared Spin Scan Radiometer (VISSR) carried by GMS-5 is composed of three infrared sensors (10.5-11.5mm 11.5-12.5mm, 6.5-7.0mm) and an array of four visual (and near IR) sensors (0.55-0.9mm). While GMS-5 itself spins at 100 revolutions per minute, sensors scan the globe from the North Pole to the South Pole in 25 minutes every hour. This makes the visual sensor array capture an image of 13376 pixels by 10000 lines with 6 bit depth. Each of the infrared sensors captures an image of 6688 pixels by 2500 lines with 8 bit depth. The resolutions on the surface right under the GMS-5 are 1.25km/pixel for the visual sensor array and 5km/pixel for each of the infrared sensors.

Captured VISSR signals are transferred to Commanding and Data Acquisition Center (CDAS) located in a suburb of Tokyo. Received VISSR signals are quality controlled and transferred to Data Processing Center (DPC) in Tokyo, then stored in magnetic disks and tape cartridges with observation parameters (time, orbit, calibration, etc.). VISSR data are available as CDROM, magnetic tape, microfilm, or printed paper from Japan Meteorological Business Support Center (JMBSC).

At the CDAS, VISSR data are also re-sampled into Stretched VISSR (S-VISSR) signals. The image size of S-VISSR data is 9166 pixels by 10000 lines for the visual images and 2293 pixels by 2500 lines for infrared images. At the same time, calibration tables of VISSR signals (0-5 volts) and digital image values (0-63 or 0-255) are generated. S-VISSR data are transmitted to GMS-5 and reflected to the ground for the Medium Scale Data Utilization Stations (MDUS). MDUS, i.g. broadcasting stations and weather forecast compa-nies, receive S-VISSR data using parabolic antenna and other facilities. Some research institutes provide images reduced from S-VISSR via anonymous FTP. Japan Meteorological Business Support Center (JMBSC) also provides monthly reduced data as CDROM.

CDAS also produces WEFAX images. VISSR data are re-sampled to 1710 pixels lines by 800 lines with 6bit depth. The latitude, longitude and coast are also drawn over the image. WEFAX images are transmitted to GMS-5 and reflected to the ground for the Small Scale Data Utilization Stations (SDUS). WEFAX images are able to be received with relatively affordable facilities ($10,000-$40,000), however overlayed coastlines cause trouble in data analysis.

As an application of GMS-5 images, the results of correlation analysis between VISSR data and surface observed global and direct irradiance are introduced.

Geostational meterological satellites and polar orbiting satellites by the World Weather Watch program
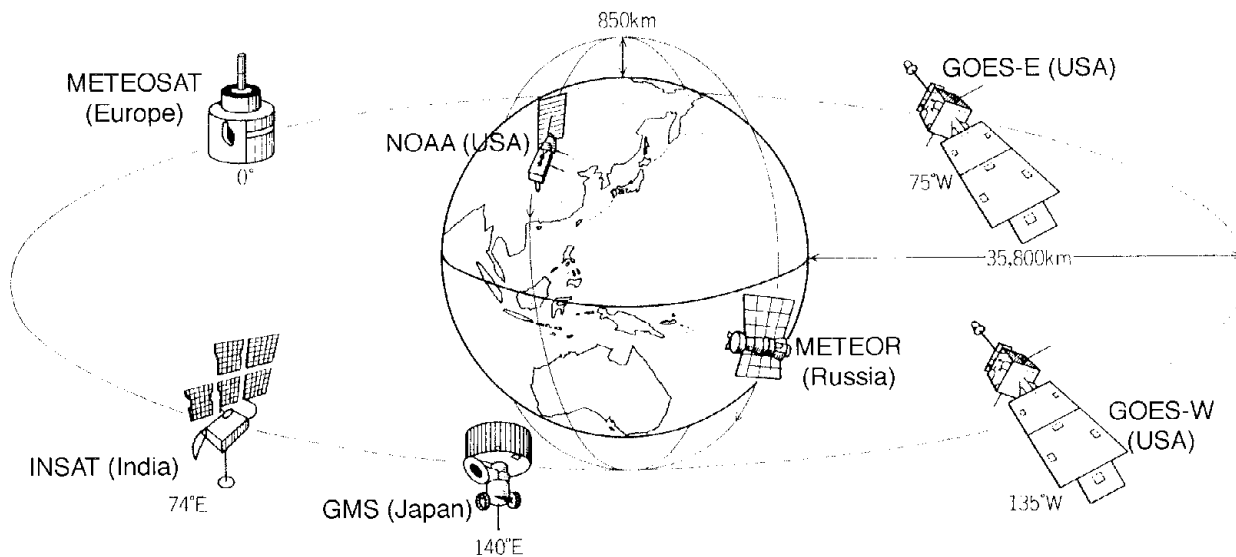
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Geostational meterological satellites operated by Japan Meteorological Agency (JMA)

Satellite	Launching date	Longtitude	Sensors	Stabilizer
GMS-1	Jul 14, 1977	140°E	VIS, IR	Spin
GMS-2	Aug 11, 1981	140°E	VIS, IR	Spin
GMS-3	Aug 3, 1984	140°E	VIS, IR	Spin
GMS-4	Aug 6, 1989	140°E	VIS, IR	Spin
GMS-5	Mar 18, 1995	140°E	VIS, IR1, IR2, IR3	Spin
MTSAT	August, 1999	140°E	VIS, IR1,IR2, IR3, IR4	Three-Axis

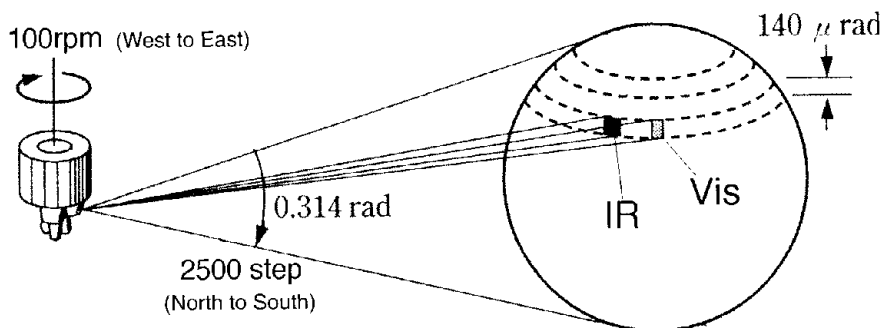Note: MTSAT (Multi-functional Transport SATellite) is planned to be operational in March 2000.

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Visible and Infrared Spin Scan Radiometer (VISSR) of GMS

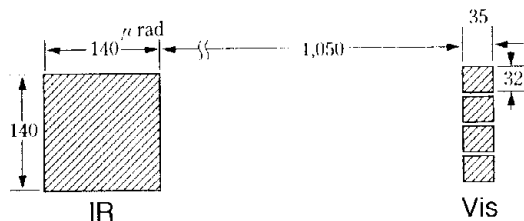| Satellite	Sensor	Channel	Wavelength [mm]	Image Resolution [pixels x lines]	Surface Resolution [km/pixel]	Quantization [bit]
GMS-5	VS	Visible & Near IR	0.55 - 0.95	13376 x 10000	1.25	6
	IR1	Split window	10.5 - 11.5	6688 x 2500	5.0	8
	IR2	Split window	11.5 - 12.5	6688 x 2500	5.0	8
	IR3	Water vapour	6.5 - 7.0	6688 x 2500	5.0	8
MTSAT	VS	Visible	0.55 - 0.80		1.0	6
	IR1	Split window	10.3 - 11.3		4.0	10
	IR2	Split window	11.5 - 12.5		4.0	10
	IR3	Water vapour	6.5 - 7.0		4.0	10
	IR4	Near IR	3.5 - 4.0		4.0	10

Scanning of the Globe

100rpm (West to East)

140 μ rad

0.314 rad

2500 step (North to South)

IR   Vis

Arrangement of visible sensor array and infrared sensor

μ rad
140
1,050
35
32
140

IR   Vis

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Data transfer between GMS-5, JMA centers and other stations

Raw VISSR
(Digital, Level 0*)

GMS-5

WEFAX (Analog, 1B*)

S-VISSR
(Digital, 1B*)

S-VISSR (Digital, 1B*)
WEFAX** (Analog, 1B*)

**Commanding and Data
Acquisition Center (CDAS)**

**Medium Scale Data
Utilization Stations (MDUS)**

**Small Scale Data
Utilization Stations (SDUS)**

Resampled VISSR
(Digital, Level 1A*)

Weather info. via TV, etc
Digital image via Internet, etc

MT,CMT, CDROM, Photo, VTR, etc.
(Level 1A - 3*) through JMBSC***

**Data Processing Center (DPC) at
Meteorological Satellite Center (MSC)**

End User

* Data levels of VISSR / S-VISSR

|	
Level 0	Raw data from sensors
Level 1A	Level 0 with parameters (time, orbit, calib, etc)
Level 1B	Converted to temparatures or albedo.
Level 2	Interpreted to meteo. elements (cloud cover, wind, etc).
Level 3	Statistically analized in spans of time and space.

** Lines of coasts, longtitude and latitude are overlayed to WEFAX images.
*** JMBSC = Japan Meteorological Business Support Center

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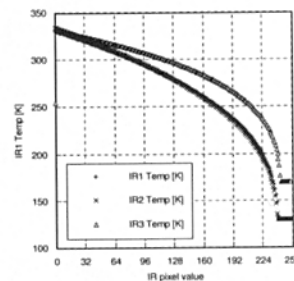

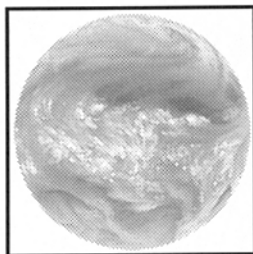# Data Format: VISSR, Stretched VISSR (S-VISSR)
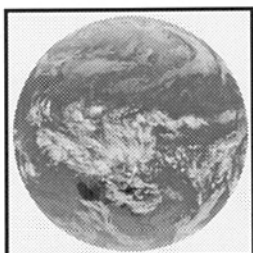
IR1: 10.5 - 11.5 μm, Split window
VISSR: 8bit, 6688 x 2500, 5km, 16MB
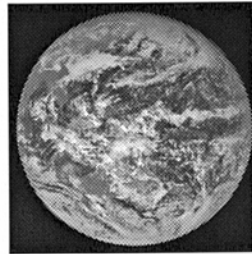S-VISSR: 8bit, 2291 x 2291, 5km, 5MB
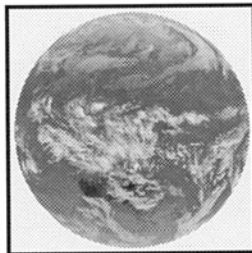
IR2: 11.5 - 12.5 μm, Split window
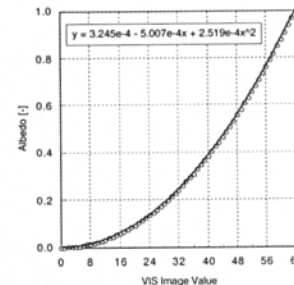VISSR: 8bit, 6688 x 2500, 5km, 16MB
S-VISSR: 8bit, 2291 x 2291, 5km, 5MB

Calibration data for IR1, IR2 & IR3

IR3: 6.5 - 7.0 μm, Water vapour
VISSR: 8bit, 6688 x 2500, 5km, 16MB
S-VISSR: 8bit, 2291 x 2291, 5km, 5MB

VIS: 0.55 - 0.95 μm, Visible & Near IR
VISSR: 6bit, 13376 x 10000, 1.25km, 96MB
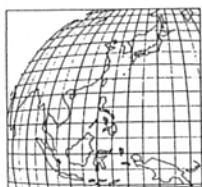S-VISSR: 6bit, 9164 x 9164, 1.25km, 60MB

$y = 3.245e\text{-}4 - 5.007e\text{-}4x + 2.519e\text{-}4x^2$

Calibration data for VIS and
the regression curve

Note: These images and calibration data were downloaded from NASA's archive (ftp://rsd.gsfc.nasa.gov/pub/Weather/GMS-5/).
MTSAT will replace the S-VISSR format with the High Resolution Imager Data (HiRID) format to send 10 bit images.

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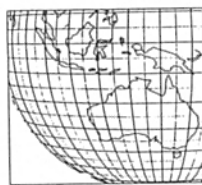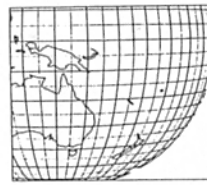
Data Format: WEFAX
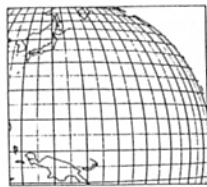
Image(A): IR1, (K): IR3   Image(B): IR1, (L): IR3
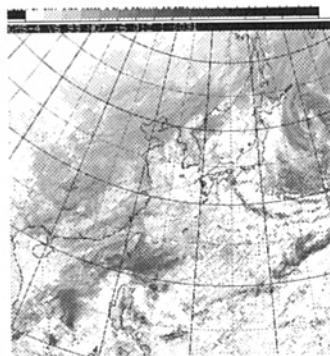
Image(C): IR1, (M): IR3   Image(D): IR1, (N): IR3

Image(I): VIS
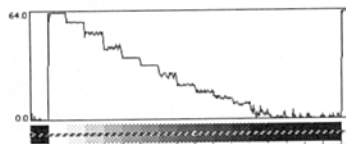
Image(H): IR1, (I): VIS
mapped by polar stereo projection, 6 bit, 800 x 800, 5km

Profile of the grayscale

Note: MTSAT will introduce the digital Low Rate Information Transmission (LRIT) in March 2000. It will quit sending the analog WEFAX in March 2003.

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Data Availability

(a) VISSR / S-VISSR Offline data (Level 1A - 3):

   Agent: Japan Meteorological Business Support Center (JMBSC) (http://www.jmbsc.or.jp)
   Media: Depends on data format (MT, CMT, CDROM, BW/color print, 16mm movie film, VTR tape, etc).
   Cost: Depends on media (ex. Meteorological Satellite Monthly Report CDROM: 2600yen=$20 per disk, MT: 8000yen)

(b) S-VISSR Realtime data (Level 1B): Medium Scale Data Utilization Stations (MDUS)

   Facility: Parabola antenna, reciever, workstation & software
   Cost: Free for the data while JMA keeps copiright. A set of facility costs approx. 40,000,000yen, excluding data strage.

(c) WEFAX Realtime data (Level 1B): Small Scale Data Utilization Stations (SDUS)

   Facility: Parabola antenna, reciever, PC & software
   Cost: Free for the data while JMA keeps copiright. A set of facility costs 1000,000-4000,000yen, excluding data strage.

(d) Voluntary MDUS through Internet (selected)
   (1) NASA and University of Hawaii (http://rsd.gsfc.nasa.gov/goesg/earth/Weather/main.html).
       S-VISSR data are converted into various formats.
       Full globe images of VIS, IR1, IR2 & IR3 with calibratio tables in HDF format are very usefull for quamtitative analysis.
       GIF and JPEG images are convenient to handle for viewing.
   (2) Institute of Industrial Science at University of Tokyo (http://www.tkl.iis.u-tokyo.ac.jp/SatIAN/Welcome.html).
       GMS-5 S-VISSR and NOAA AVHRR are received with parabola antennas.
       The 100TB strage never overflows.
   (3) Department of Information Science, Kochi University (http://weather.is.kochi-u.ac.jp/archive-e.html).
       S-VISSR data from IIS, Univ. Tokyo are transformed into longitude/latitude coordinate in various resolutions.
       The square images are more convenient than NASA's full disk images for quantitative analysis.
       Downloading a lot of data in one stroke is forbidden because the lower capacity of Internet in Japan.

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Medium Scale Data Utilization Stations (MDUS)
Institute of Industrial Science, Univ. Tokyo

S-VISSR

Satellite Image Receiving, Processing and Archiving System

3.7m Parabolic Antenna
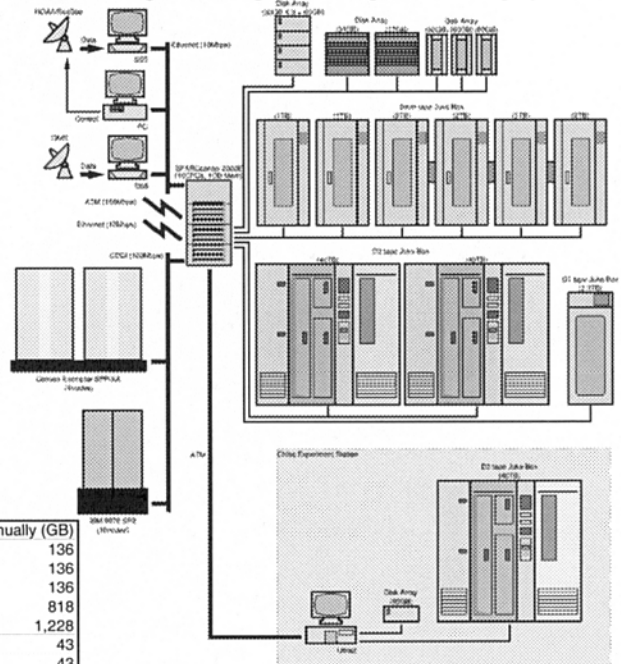
Annual requirement for data strage

Image type	bit/pixel	pixel	line	Hourly (MB)	Daily (MB)	Monthly (GB)	Annually (GB)
VISSR (IR1)	8	6,688	2,500	16	383	11	136
VISSR (IR2)	8	6,688	2,500	16	383	11	136
VISSR (IR3)	8	6,688	2,500	16	383	11	136
VISSR (VIS)	6	13,376	10,000	96	2,296	67	818
VISSR (Total)				144	3,444	101	1,228
S-VISSR (IR1)	8	2,291	2,291	5	120	4	43
S-VISSR (IR2)	8	2,291	2,291	5	120	4	43
S-VISSR (IR3)	8	2,291	2,291	5	120	4	43
S-VISSR (VIS)	6	9,164	9,164	60	1,442	42	514
VISSR (Total)				75	1,802	53	642

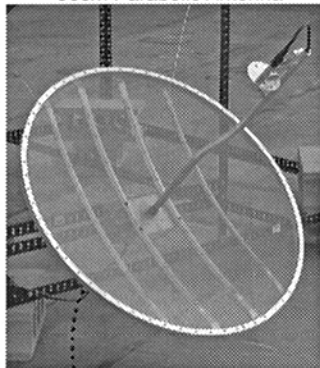**2ND Workshop on Satellite for Solar Energy Assessments, February 3-4, 1999, Golden, Colorado, USA**

Small Scale Data Utilization Stations (SDUS)
Department of Architecture, Fukuyama University

WEFAX

PC with the interface board

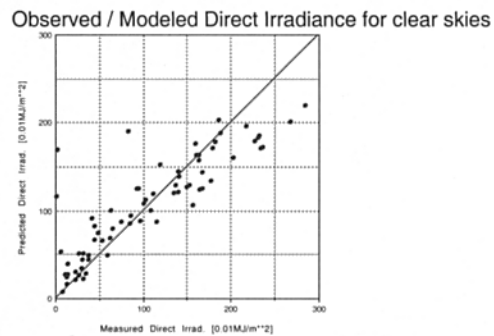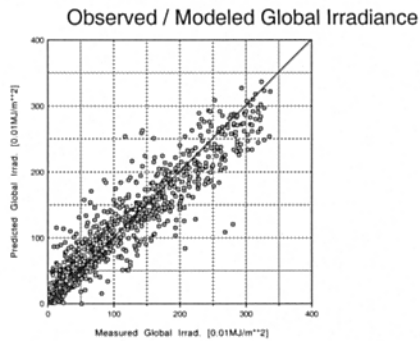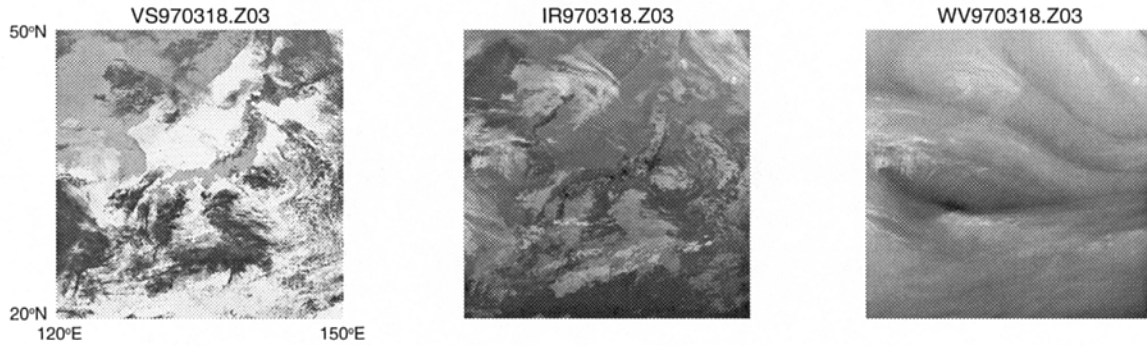90cm Parabolic Antenna

1691GHz Reciever

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Application of GMS-5 data

Regression analisys of global irradiance and direct irradiance

Satellite data: VISSR images and calibration data by Meteorological Satellite Monthly Report CDROM (JMBSC).
Surface data: Global irrad., direct irrad., cloud amount, etc. obserbed by the Fukuoka Meteorological Observatory.
Total # of data: 2857 set (hourly data from July 1, 1996 to March 31, 1997)

VS970318.Z03   IR970318.Z03   WV970318.Z03

Observed / Modeled Global Irradiance

Observed / Modeled Direct Irradiance for clear skies

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Acknowledgements

References

(1) Kiyoshi Tuchiya: Remote Sensing Gai-ron, Asakura sho-ten, 1990 (in Japanese).
(2) Kisho(Meteorological) Handbook, Asakura sho-ten, 1995 (in Japanese).
(3) Zukai Kisho-no-Daihyakka, Ohm-sha, 1997 (in Japanese).
(4) Kisho-gaku-Jiten, Tokyo-shoseki, 1998 (in Japanese).
(5) S. Q. Kidder, T. H. Vonder Haar: Satellite Meteorology-an Introduction, Academic Press, 1995.

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